



The bright pink lights of the VEGGIE system undergoing testing inside the International Space Station Environmental Simulator chamber at the Space Station Processing Facility (SSPF) at NASA's Kennedy Space Center
// PHOTO COURTESY OF NASA //

ORBITAL TECHNOLOGY CORPORATION (ORBITEC)

A standard six-month mission to the International Space Station can certainly have its life changing and awe-inspiring moments for the crew. Mealtime, however, is not one of those moments. Astronauts have come to rely on prepackaged, freeze-dried foods to nourish them during these lengthy expeditions.

PROJECT
Deployable Vegetable
Production Unit (VEGGIE)

MISSION DIRECTORATE
Human Exploration and
Operations

PHASE III SUCCESS
\$1.34 million directly related to
VEGGIE; additional multimillion
dollar contracts for technologies
that stemmed from the VEGGIE
SBIR project

SNAPSHOT
Through the NASA SBIR program,
ORBITEC developed VEGGIE,
which is currently in use aboard
the ISS to grow fresh vegetables,
plants and flowers. A second
VEGGIE unit is set to join its
counterpart in 2016

**ORBITAL TECHNOLOGIES
CORPORATION (ORBITEC)**
Space Center
1212 Fourier Drive
Madison, WI 53717

Although modern science has come a long way in providing nutrient-rich foods to astronauts, whole foods like vegetables and leafy greens were not available on-orbit. That is, until Orbital Technologies Corporation (ORBITEC) introduced the Vegetable Production System (VEGGIE) – a game-changing technology that enables the growth of plants and vegetables in space. With support from NASA's Small Business Innovation Research (SBIR) program, VEGGIE grew from an idea envisioned by a team of horticulturists and engineers, to a system in use today aboard the ISS and one that is redefining NASA's new era of space exploration.

"Based on past research, we believed there was a significant physiological advantage to having fresh food available to the crew," recalls Robert Morrow, Senior Scientist at ORBITEC. "So we proposed a simplified plant growth system for food supplementation, and eventually received an SBIR award to help further develop that concept."

The team at ORBITEC dove into their vision – a vision that did not fully come to fruition until 18 years after the concept was developed. This first-of-its-kind system had to meet some stringent requirements; it needed a light source that could sufficiently produce crops, a compressible nutrient and water delivery system, and it would require a semi-passive atmospheric control system that minimizes water use without limiting air flow around the plants. VEGGIE would also need to run on low power and utilize the cabin environment for temperature control and as a source of CO₂. The end result was a system that operated with only 70 watts of power, which is equivalent to a standard light bulb.

ORBITEC, based in Madison, Wisconsin, won a Phase II award worth \$600,000 just one year after its Phase I, to continue this promising development and meet all of these objectives. After several high-fidelity prototypes were built by ORBITEC, and tested by both ORBITEC and NASA Kennedy Space Center (KSC) scientists, VEGGIE made its debut onboard the ISS in 2014 when it launched on the Space X Dragon 4 capsule.

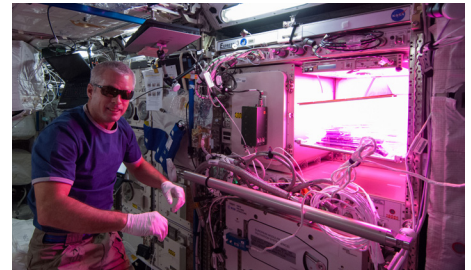
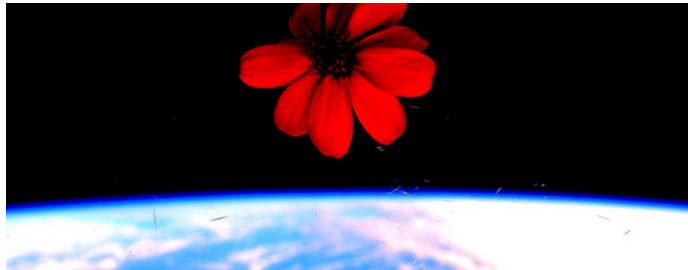
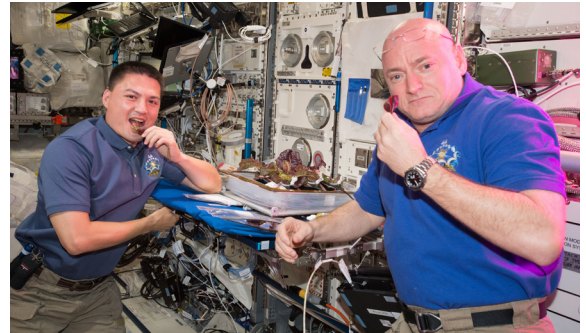
UPPER LEFT NASA Administrator Charlie Bolden, Dr. Marshall Porterfield, and Mr. Angel Otero supported the VEGGIE effort, with a display at NASA HQ in Washington DC

UPPER RIGHT Astronauts Lindgren and Kelly enjoying fresh lettuce grown in the ISS

BOTTOM LEFT NASA's "one-year astronaut" Scott Kelly tweeted this flower that was grown on VEGGIE – marking the very first time an ornamental flower was grown in space

BOTTOM RIGHT NASA Astronaut Steve Swanson activates the VEGGIE machine aboard the ISS

// PHOTOS COURTESY OF NASA //



Seeds for romaine lettuce and zinnia flowers also accompanied the system for the astronauts to grow in space. Expedition 39 flight engineer Steve Swanson started the lettuce seeds in May 2014. Thirty-three days later, the plants were harvested and flown back to Earth where they were tested for food safety at KSC. Soon thereafter, the second round of plants were activated by astronaut Scott Kelly – but this time, the crew enjoyed eating the

romaine lettuce. The zinnia flower had also bloomed, marking the very first ornamental flower that was grown in space.

"The crew was so excited to have fresh food onboard," says Robert Richter, Program Manager for Veggie at ORBITEC. "Some of the best feedback we got was from Astronaut Kjell Lindgren. He said the ISS is a very sterile environment and just having plants near him provided the color and relaxation that he had been missing."

The implications of VEGGIE go far beyond providing sustenance and relief to the crew of the ISS. The ability to grow food in space is important for NASA's anti-

ipated long duration missions to Mars and other planetary expeditions, where astronauts could be away from Earth for years at a time.

VEGGIE came on the heels of another highly successful ORBITEC project – the Biomass Production System (BPS). Concurrently with the initial development of VEGGIE, ORBITEC was developing the Plant Research Unit (PRU) which was awarded the largest NASA follow-on contract ever at the time. Today, ORBITEC is working on two

other large-scale projects, which utilize some of the same technology developed under BPS and VEGGIE, including an Advanced Plant Habitat and a NextSTEP Hybrid Life Support System. The company is looking at hybrid life support systems which incorporate both biological and physical-chemical systems and looking at testing larger plant growth systems to improve these technologies for long duration space missions.

"VEGGIE is a stepping stone for long duration systems focused on life support," adds Morrow. "This feeds into a number of scientific aspects; but they all lean toward plant biology in space."

The overall vision of the company attracted Sierra Nevada Corporation – the top woman-owned federal contractor in the United States, which acquired ORBITEC in 2014. Sierra Nevada wanted to add to its Space Systems capabilities, and through this acquisition, was able to add to its technology portfolio in the areas of strong liquid rocket propulsion systems, human space flight life support and thermal systems, automated life science systems, and fire suppression systems. ORBITEC, which began as a 3-person team, will continue to operate out of its Wisconsin headquarters, where it has built a name for itself in the international aerospace community.

"The NASA SBIR program played a key role to our commercial success, and the eventual acquisition by Sierra Nevada Corporation," says Richter. "The funding we received for BPS enabled us to develop VEGGIE and supported us to where we are today. Without the SBIR program, we literally would not have gotten off the ground."

The second VEGGIE system is set to join its counterpart on the ISS with the launch of SpaceX 14 in 2016.

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ORBITEC
PROGRAM MANAGER FOR VEGGIE
ROBERT RICHTER